REMARKS

Applicant respectfully requests reconsideration. Claims 1, 4, 7-14, 18-28, 30-35 and 86-90 were previously pending in this application. Claim 32 has been cancelled. No new matter is being added. Accordingly, claims 1, 4, 7-14, 18-28, 30-31, 33-35 and 86-90 are pending for examination with claims 1 and 86 being independent.

Rejection of Claims Under 35 U.S.C. §102/103

Claims 1, 4, 7-14, 18-24, 26-28, 32-35, 87-88 and 90 were rejected under 35 U.S.C. §102(b) as being anticipated by or, in the alternative, under 35 U.S.C. §103(a) as obvious over U.S. Patent No. 5,874,747 (Redwing).

Independent claim 1 is directed to a semiconductor material that comprises a thick gallium nitride material region (i.e., greater than 0.5 microns) having a low crack level (i.e., less than 0.005 $\mu m/\mu m^2$) formed on a *silicon* substrate. (Emphasis added). In contrast, Redwing's structures include gallium nitride material regions formed on *silicon carbide* substrates. (Emphasis added). Though the "Description of Related Art" in Redwing refers generally to GaN growth on silicon substrates (Column 4, lines 62-65), there is no structure in any embodiment of Redwing's invention (as described in the "Summary of the Invention" or the Detailed Description of the Invention") that includes any type of gallium nitride material region formed on a silicon substrate, much less a gallium nitride material region formed on a silicon substrate having the claimed thickness and crack level.

In fact, Redwing teaches away from structures that include a gallium nitride material region and a silicon substrate as claimed. Redwing is directed to gallium nitride-based light emitting devices. An object of Redwing's invention is to "provide bright green-blue to ultraviolet light emitting devices with high optical efficiency, ..." (See, e.g., Redwing, Col. 6, lines 29-32.) Throughout the specification, Redwing repeatedly stresses the desirability and importance of employing a silicon carbide substrate. (See, e.g., Redwing, Col. 4, lines 10-51.) In particular, Redwing notes the importance of using a silicon carbide substrate in obtaining the desired light emission properties:

> The present invention is based on the discovery that by using **silicon carbide** of a selected prototype and growing Ga*N on that substrate in selected orientations, light emitting devices, e.g., a **green-blue to ultraviolet emitting laser or a green-blue to ultraviolet emitting diode,** of surprisingly high quantum efficiency and luminous efficiency may be fabricated. The luminescence efficiency, charger carrier mobilities and transmittance of light are improved.
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> The substrate polytype and orientation are selected to optimize the performance of the light emitters. The properties that figure most strongly in this selection are crystal structure, charger carrier mobilities, and **transparency of the substrate to light of the wavelengths desirably emitted by the light emitters.** (Emphasis added) (Redwing, Col. 9, lines 54-67)

Redwing further stresses that "optical properties of the substrate are also important" because in light emitting devices "a great deal of light can come from out of the substrate." (See, e.g., Redwing, Col. 11, lines 13 and 20-21.). Visible light (e.g., green-blue to ultraviolet) may be readily transmitted through silicon carbide substrates. (See, e.g., Redwing, Column 9, lines 54-66; FIGS. 2 and 3.) In contrast, visible light at these wavelengths is **absorbed** by silicon substrates, rather than being transmitted. (Emphasis added).

If the Redwing devices included a silicon substrate as suggested in the Office Action, the devices would transmit significantly less light in the desired wavelength range. Thus, the devices would not be effective (and, likely would be inoperable) for their intended purpose of emitting light in this range. Thus, Redwing even teaches away from structures including silicon substrates.

Moreover, there would have been no reasonable expectation at the priority date of the '798 application (i.e., December 14, 2000) that the semiconductor material of claim 1 could be successfully formed in view of the teachings in Redwing. In particular, it would not have been expected that a thick (i.e., greater than 0.5 micron) gallium nitride material region having a low crack level (i.e., less than 0.005 micron/micron^2) could be formed over a silicon substrate. There would have been no reasonable expectation for success because of the significant challenges associated with growing gallium nitride materials on silicon substrates. The challenges include large thermal expansion coefficient differences, as well as large lattice constant differences, between gallium nitride materials and silicon. Such differences can lead to cracking in gallium nitride material regions formed over silicon substrates, particularly in thick gallium nitride material regions as claimed, amongst other problems. Such differences between gallium nitride materials and silicon

are significantly greater than the thermal expansion coefficient and lattice constant differences between gallium nitride materials and silicon carbide. Thus, the difficulty in forming structures including a gallium nitride material region formed over a silicon substrate is significantly greater than forming structures including a gallium nitride material region formed on a silicon carbide substrate as described in Redwing.

Because Redwing fails to teach or suggest each claim limitation, independent claim 1 is patentable over Redwing for at least this reason. Moreover, because there would have been no reasonable expectation of successfully forming the semiconductor material of claim 1 in view of the teachings in Redwing, independent claim 1 are also not obvious in view of Redwing. The remaining claims that stand rejected on this ground all depend from claim 1 and, thus, are patentable over Redwing for at least this reason.

Accordingly, withdrawal of the claims rejections on this ground is respectfully requested.

Rejection of Claims Under 35 U.S.C. §102

Claims 1, 4, 7-14, 19-23, 25-28, 32-33, 35 and 88-90 were rejected under 35 U.S.C. §102(e) as being anticipated by U.S. Patent Publication No. 2002/0020341 (Marchand).

Claim 1 has been amended to recite that the material includes an intermediate layer comprising a nitride material formed over the silicon substrate and under the transition layer. Marchand fails to teach or suggest a material as recited in claim 1. The remaining claims that stand rejected on this ground depend from claim 1 and, thus, are patentable over Marchand for at least this reason.

Accordingly, withdrawal of the claims rejections on this ground is respectfully requested.

Rejection of Claims Under 35 U.S.C. §103

Claims 25, 30-31 and 86 were rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 5,874,747 (Redwing) in view of U.S. Patent No. 6,426,512 (Ito) and further in view of U.S. Patent No. 6,287,947 (Ludowise).

It appears that the combination of Redwing and Ito is being relied upon for the rejection of claims 25, 30 and 86; and that Ludowise is being added to this combination for the rejection of dependent claim 31 which recites a substrate that is textured.

The Office Action states that it would have been obvious to one of ordinary skill in the art to modify the semiconductor device of Redwing with the silicon substrate of Ito. One of ordinary skill in the art would not have been motivated to combine Redwing and Ito in the manner suggested in the Office Action and, in fact, Redwing teaches away from such a modification as noted above.

Redwing is directed to gallium nitride-based light emitting devices. An object of Redwing's invention is to "provide bright green-blue to ultraviolet light emitting devices with high optical efficiency, ..." (See, e.g., Redwing, Col. 6, lines 29-32.) The Redwing device structures include a gallium nitride layer (or layers) formed on a silicon carbide substrate. Throughout the specification, Redwing repeatedly stresses the desirability and importance of employing a silicon carbide substrate. (See, e.g., Redwing, Col. 4, lines 10-51.) In particular, Redwing notes the importance of using a silicon carbide substrate in obtaining the desired light emission properties:

> The present invention is based on the discovery that by using **silicon carbide** of a selected prototype and growing Ga*N on that substrate in selected orientations, light emitting devices, e.g., a **green-blue to ultraviolet emitting laser or a green-blue to ultraviolet emitting diode,** of surprisingly high quantum efficiency and luminous efficiency may be fabricated. The luminescence efficiency, charger carrier mobilities and transmittance of light are improved.
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> The substrate polytype and orientation are selected to optimize the performance of the light emitters. The properties that figure most strongly in this selection are crystal structure, charger carrier mobilities, and **transparency of the substrate to light of the wavelengths desirably emitted by the light emitters.** (Emphasis added) (Redwing, Col. 9, lines 54-67)

Redwing further stresses that "optical properties of the substrate are also important" because in light emitting devices "a great deal of light can come from out of the substrate." (See, e.g., Redwing, Col. 11, lines 13 and 20-21.). Visible light (e.g., green-blue to ultraviolet) may be readily transmitted through silicon carbide substrates. (See, e.g., Redwing, Column 9, lines 54-66; FIGS. 2 and 3.) In contrast, visible light at these wavelengths is **absorbed** by silicon substrates, rather than being transmitted. (Emphasis added). If the Redwing devices included a silicon substrate as suggested in the Office Action, the devices would transmit significantly less light in the desired

wavelength range. Thus, this modification would render the Redwing devices inferior (and, likely inoperable) for their intended purpose of emitting light in this range. One of ordinary skill in the art, therefore, would not have been motivated to make this modification for at least this reason.

Accordingly, Applicant respectfully submits that a prima facie case of obviousness has not been met with respect to the claim rejections in view of the combination of Redwing in view of Ito (and Ludowise).

Applicant also submits that one of ordinary skill in the art would not have been motivated to combine Redwing in view of Ito an further in view of Ludowise. Applicant also notes that Ludowise fails to teach or suggest a silicon substrate as claimed. The Office Action refers to "silicon containing materials" disclosed in Ludowise, but Applicant notes that such materials appear to be limited to silicon dioxide and silicon carbide – neither of which is a silicon substrate.

Moreover, even if one combined the teaching of Redwing and Ito (and Ludowise) as stated in the Office Action, there would have been no reasonable expectation of success in forming a semiconductor material comprising a thick (i.e., greater than 0.5 micron) gallium nitride material region having a low crack level (i.e., less than 0.005 micron/micron^2) over a silicon substrate. As noted above, there would have been no reasonable expectation for success because of the significant challenges associated with growing thick, low crack level gallium nitride materials on silicon substrates. The challenges include large thermal expansion coefficient differences, as well as large lattice constant differences, between gallium nitride materials and silicon. Such differences can lead to cracking in gallium nitride material regions formed over silicon substrates, particularly in thick gallium nitride material regions as claimed, amongst other problems. Such differences between gallium nitride materials and silicon are significantly greater than the thermal expansion coefficient and lattice constant differences between gallium nitride materials and the silicon carbide substrates taught in Redwing. Thus, the difficulty in forming structures including a thick, low crack level gallium nitride material region formed over a silicon substrate is significantly greater than forming structures including a gallium nitride material region formed on a silicon carbide substrate as described in Redwing.

Ito's use of a silicon substrate does not suggest, to one of ordinary skill in the art, the ability to form thick, low crack level gallium nitride material regions on silicon substrates as claimed,

particularly substrates having a large area (i.e., greater than about 4 inches) as recited in independent claim 86.

Because Redwing teaches away from being combined with Ito (and Ludowise) in the manner suggested in the Office Action and there would have been no reasonable expectation of success of forming the claimed structures in view of the combined teachings, claims 25, 30-31 and 86 are not obvious in view of the asserted combinations for at least these reasons.

Accordingly, withdrawal of the claims rejections on this ground is respectfully requested.

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Respectfully submitted,

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